ORIGINAL ARTICLE
Emergency & Critical Care Medicine

JKMS

DOI: 10.3346/jkms.2011.26.1.124 • J Korean Med Sci 2011; 26: 124-130

Risk Stratification-based Surveillance of Bacterial Contamination in Metropolitan Ambulances

Hyun Noh[1], Sang Do Shin[1], Nam Joong Kim[2], Young Sun Ro[1], Hyang Soon Oh[3], Se Ik Joo[4], Jung In Kim[5], and Marcus Eng Hock Ong[6]

[1]Departments of Emergency Medicine and [2]Internal Medicine, Seoul National University College of Medicine, Seoul; [3]Infection Control Service, [4]Department of Clinical Laboratory, Seoul National University Hospital, Seoul; [5]Department of Occupational & Environmental Health, Seoul National University Graduate School of Public Health, Seoul, Korea; [6]Department of Emergency Medicine, Singapore General Hospital, Singapore

Received: 19 June 2010
Accepted: 26 October 2010

Address for Correspondence:
Sang Do Shin, MD
Department of Emergency Medicine, Seoul National University College of Medicine, 101 Daehang-no, Jongno-gu, Seoul 110-744, Korea
Tel: +82.2-2072-3257, Fax: +82.2-741-7855
E-mail: shinsangdo@medimail.co.kr

We aimed to know the risk-stratification-based prevalence of bacterial contamination of ambulance vehicle surfaces, equipment, and materials. This study was performed in a metropolitan area with fire-based single-tiered Basic Life Support ambulances. Total 13 out of 117 ambulances (11.1%) were sampled and 33 sites per each ambulance were sampled using a soft rayon swab and aseptic containers. These samples were then plated onto a screening media of blood agar and MacConkey agar. Specific identification with antibiotic susceptibility was performed. We categorized sampling sites into risk stratification-based groups (Critical, Semi-critical, and Non-critical equipment) related to the likelihood of direct contact with patients' mucosa. Total 214 of 429 samples showed positive results (49.9%) for any bacteria. Four of these were pathogenic (0.9%) (MRSA, MRCoNS, and *K. pneumoniae*), and 210 of these were environmental flora (49.0%). However, the prevalence (positive/number of sample) of bacterial contamination in critical, semi-critical airway, semi-critical breathing apparatus group was as high as 15.4% (4/26), 30.7% (16/52), and 46.2% (48/104), respectively. Despite current formal guidelines, critical and semi-critical equipments were contaminated with pathogens and normal flora. This study suggests the need for strict infection control and prevention for ambulance services.

Key Words: Bacterial Infections; Contamination; Ambulances

INTRODUCTION

Ambulances can possibly be a source for various pathogens to be transmitted because they transport many patients with various diseases or infections. To prevent the ambulance from being a source for transmission of infection to patients or ambulance crews, strict infection control protocols should be implemented and monitored. Ambulance services are increasingly being recognized around the world as being an important part of public health system. However, although hospital-based infection control programs are being currently emphasized (1-3), prehospital infection control has not been recognized as an essential part of public health. Existing research related to prehospital infection have usually been regarding the prevalence of pathogens in samples from the surface of ambulances or devices, contamination rates of specific pathogens, and the possibility of sterilization for the cultured microorganisms (4-6). To prevent the ambulance from being a source of contamination, we should have an evidence-based and cost-effective infection control protocol for ambulances and its equipment. Medical devices and material are usually classified into three categories (critical, semi-critical, and non-critical) according to the likelihood of being contaminated (7). For example, devices like the blade of laryngoscope, being directly in contact with the airway mucous membrane of patients, are considered as a critical device. Because ambulance devices and materials are too many and very various, this schematic approach according to this risk stratification-based surveillance (RSS) for contamination will be very helpful for the implementation and quality assurance of infection control.

Few studies on the prevalence of microorganism according to RSS (Critical, Semi-critical, Non-critical) have been done. This RSS-based prevalence will help ambulance authorities make a cost-effective infection control guideline and monitoring system.

This study aimed to know the prevalence of microorganism contaminated in ambulance devices and material according to RSS.

MATERIALS AND METHODS

Study design and setting

This study was a surveillance and descriptive study. This study was done in a metropolitan emergency medical service (EMS),

pISSN 1011-8934
eISSN 1598-6357

which is a single tiered, fire-based, basic life support (BLS) EMS. The metropolitan city has about 10 million population, 250,000 annual ambulance transports in 2008, and 117 ambulances for prehospital transport.

The metropolitan ambulance authority (city fire department) follows the national standard operating procedures (SOP) for infection control which was first made by the national headquarters of the fire department in 2005. The national SOP included the goal of infection control, role of EMS authority, infection control committee and education program, environmental control of the ambulance station, personal protective equipment, field precautions and post-return precautions. This was revised to be stricter in January 2008. According to these SOP, ambulance crews should wash the decontaminated surface of ambulances using an appropriate cleaner, sterilize the devices, and change the material if disposable.

Selection of sampling sites

We used a convenience sampling method. Sampling time also decided with a convenience method. Among 117 ambulances, 13 ambulances (11.3%) were selected. For each ambulance, the same thirty three sampling sites were decided (total 429 sites), according to risk stratification. Each sampling was also categorized according to type of device: airway devices, breathing devices, circulation devices, other devices, and ambulance apparatus. Driver site was used as a control (Table 1). Sampling was done with blinding to ambulance crews in April, 2009.

Data collection and processing

Sampling was done by surface swabbing using soft rayon swabs (COPAN Italia S.p.A., Brescia, Italy). The samples were put on the blood agar plate and MacConkey agar plate and then screening was done for Methicillin-resistant *Staphylococcus aureus* (MRSA) and Vancomycin-resistant *Enterococcus* (VRE) contamination. Fluid samples were put into an aseptic container and transported to the microbiology laboratory center of the study institution for cultivation. Fluid from the oxygen filter tank or suction bottle was filtered using an analytical test filter funnel with 0.2 μm size and samples from surface of the filter were swabbed and tested for *Legionella* antigen. After one night, the fluids were also put on blood agar and MacConkey agar plates and then screening was done for MRSA and VRE contamination. Interpretation was done by the certified board of the division of microbiology (laboratory medicine) as a routine clinical interpretation.

Outcome measures and primary data analysis

We investigated the positive rate for whole bacteria including

Table 1. Sampling sites according to risk stratification for contamination

Devices	Critical	Semi-critical	Non-critical
Airway devices	LMA cuff Intubation tube	Laryngoscope blade Suction tip Water in suction bottle Oropharyngeal airway	Laryngoscope handle
Breathing devices		Nasal prong Facial mask BVM mask BVM bag Oxygen gate connector Oxygen generator Water in oxygen generator Bottom of oxygen generator-inside	
Circulation devices			ECG line Handle of AED Button of AED Handle of sphygmomanometer Detector of pulse oxymetry
Other devices			Splint for upper extremity Splint for lower extremity Cervical collar Spine board Patient's side door handle-1 Patient's side door handle-2 Stretcher car handle Stretcher car side bar Surface of stethoscope
Ambulance apparatus			Extractor fan Air conditioner
Control			Steering wheel Driver's side door handle

LMA, laryngeal mask airway; BVM, bag valve mask; ECG, electrocardiography; AED, automatic external defibrillator.

MRSA and VRE for the 429 samples according to risk stratification groups (Critical, Semi-critical, and Non-critical). We calculated the positive culture rate and its 95% confidence intervals (95% CIs) for descriptive analysis.

Ethics statement

This study was exempted for review by the institutional board review of the Seoul National University Hospital because this study did not enroll human subjects or animals.

RESULTS

Demographics of participating ambulance

All ambulances participating in this study had very similar configuration to type II of Federal Specification for Ambulances KKK-A-1822 of the USA (8) and were made in Korea. Demographics on patient transport of participating ambulances of 2008 were described in Table 2. Daily average transport volume per a ambulance was 6.6 per a day (range 4.8-8.4). Male was 42.3% (range 34.0%-46.7%) and mean age was 50.8 ± 21.4. Proportion of respiratory symptom or fever was 6.6% and 1.7%, respectively.

Prevalence rate of microorganisms according to sampling site

The total positive culture rate among 429 samples was 214 (49.9%, 95% CI; 45.1%-54.7%), which was the highest for circulation devices (69.2%, 95% CI; 56.6%-80.1%) and the lowest in ambulance apparatus (19.2%, 95% CI; 6.6%-39.4%) (Table 3). Critical, semi-critical, and non-critical devices showed 15.4% (95% CI, 4.4%-34.9%), 41.0 (95% CI, 33.2%-49.2%), and 59.1% (95% CI, 44.0%-57.9%), respectively. Pathogens were found the following four sites; 1) Extended spectrum beta lactamase (ESBL) positive-*Klebsiella pneumoniae* in the water of suction bottles (airway devices). 2) ESBL positive-*K. pneumoniae* in the Bag-Valve Mask (BVM) bag (breathing devices). 3) Methicillin resistant coagu-

Table 3. Prevalence rate of microorganisms according to risk stratification-based sampling sites

Sites of sampling	Total	Positive, total				Remark, pathogen
	No.	No.	%	95%	CI*,†	
Airway devices*	91	23	25.3	16.7	35.5	1 *K. pneumoniae*[1]
Critical	26	4	15.4	4.4	34.9	
Semi-critical	52	16	30.8	18.7	45.1	
Non-critical	13	3	23.1	5.0	53.8	
Breathing devices, semi-critical	104	48	46.2	36.3	56.2	1 *K. pneumoniae*[2]
Circulation devices, non-critical	65	45	69.2	56.6	80.1	
Other devices, non-critical	117	74	63.2	53.8	72	1 MRCoNS[3]
Ambulance apparatus, non-critical	26	5	19.2	6.6	39.4	
Driver's side (control), non-critical	26	19	73.1	52.2	88.4	I MRSA[4]
Total	429	214	49.9	45.1	54.7	
Critical	26	4	15.4	4.4	34.9	
Semi-critical	221	64	41.0	33.2	49.2	
Non-critical	208	146	59.1	44.0	57.9	

*Critical airway equipments were intubation tube and laryngeal mask airway cuff. Semi-critical airway equipments were laryngoscope blade, suction tip, water in suction bottle and oropharyngeal airway. Laryngoscope handle was classified into noncritical equipment. All breathing devices were semi-critical group. Circulation, and other devices, ambulance apparatus, and driver's side was non-critical group. 1) One Extended spectrum beta lactamase (ESBL) positive-*K. pneumoniae* was cultured in water of suction bottle among airway equipment; 2) One ESBL positive-*K. pneumoniae* was cultured in BVM bag among breathing equipment; 3) One Methicillin resistant Coagulase Negative *Staphylococcus* was cultured in stretcher car side bar; 4) One Methicillin resistant *Staphylococcus aureus* was cultured in driver's side door handle; †95% confidence interval.

Table 2. Demographic findings of transported patients by ambulance in 2008

Ambulance	Call volume, total	Average, daily	Male		Age (yr) (mean ± SD)	Symptom (%)						
	No.	No.	No.	%		Respiratory	Cardiovascular	Neurologic	Gastrointestinal	Pain, NOS	Fever	Others
Total (n = 117)	250,596	5.9	109,446	43.7	49.7 ± 21.8	6.4	4.2	24.0	18.6	46.3	2.1	18.0
Target ambulance (n = 13)	31,382	6.6	13,281	42.3	50.8 ± 21.4	6.6	4.4	22.7	16.8	47.3	1.7	17.5
A	3,072	8.4	1,044	34.0	49.1 ± 19.1	7.0	4.4	24.8	20.0	46.9	1.6	16.3
B	2,113	5.8	866	41.0	51.0 ± 21.1	4.9	3.8	20.6	16.6	59.2	0.9	13.6
C	2,087	5.7	865	41.4	48.3 ± 20.8	7.0	4.8	22.5	17.3	58.7	1.7	4.3
D	1,750	4.8	689	39.4	46.0 ± 20.3	4.5	4.9	27.1	19.9	50.4	1.0	22.4
E	2,227	6.1	1,036	46.5	49.9 ± 22.3	6.1	5.1	20.7	16.0	38.7	3.9	16.5
F	2,648	7.3	1,211	45.7	51.6 ± 21.3	8.0	5.1	27.6	20.2	41.4	1.1	21.2
G	2,036	5.6	785	38.6	51.2 ± 20.8	5.5	3.5	19.9	11.6	58.4	1.0	9.2
H	2,603	7.1	1,042	40.0	53.2 ± 19.3	5.8	3.3	19.4	13.7	38.8	1.0	26.7
I	2,661	7.3	1,242	46.7	52.1 ± 23.1	4.9	5.3	21.9	14.8	40.7	2.2	19.9
J	2,815	7.7	1,310	46.5	53.4 ± 23.0	8.5	4.2	25.8	16.7	45.7	1.8	13.7
K	2,905	8.0	1,311	45.1	51.8 ± 22.7	7.2	4.4	21.4	18.1	45.6	1.9	15.8
L	2,339	6.4	1,007	43.1	52.0 ± 21.3	8.1	4.2	21.0	16.9	51.7	1.5	12.1
M	2,126	5.8	873	41.1	49.0 ± 20.9	6.5	3.9	22.0	15.8	46.9	2.9	14.4

NOS, not otherwise specified.

DOI: 10.3346/jkms.2011.26.1.124

lase negative *Staphylococcus* (MRCoNS) in stretcher side bars (other devices). 4) MRSA in the driver's side door handle (Control site).

Table 4. Identification of microorganism: environmental and normal flora

Classification*	Name of bacteria	Count, No.	Subtotal, No. (%)
Total		423	423 (100.0)
GNR-F	*Enterobacter cloacae*	1	16 (3.8)
	Klebsiella pneumoniae	2	
	Leclercia adecarboxylata	1	
	Pantoea agglomerans	5	
	Pantoea species	5	
	Serratia marcescens	1	
	Unidentified Gram (-) bacilli, fermentor	1	
GNR-NF	*Acinetobacter baumannii*	3	64 (15.1)
	Acinetobacter haemolyticus	1	
	Acinetobacter radioresistens	5	
	Acinetobacter species	2	
	Chryseomonas luteola	8	
	Delftia acidovorans	6	
	Pseudomonas aeruginosa	1	
	Pseudomonas oryzihabitans	15	
	Pseudomonas species	5	
	Pseudomonas stutzeri	5	
	Sphingomonas paucimobilis	3	
	Stenotrophomonas maltophilia	3	
	Unidentified Gram (-) bacilli, non-fermentor	7	
GPC-E	*Enterococcus casseliflavus*	1	5 (1.2)
	Enterococcus faecalis	4	
GPC-M	*Kocuria varians*	1	54 (12.8)
	Kytococcus species	1	
	Micrococcus species	52	
GPC-S	Coagulase Negative *Staphylococcus*	38	46 (10.9)
	Staphylococcus aureus	4	
	Staphylococcus hominis	2	
	Staphylococcus simulans	1	
	Staphylococcus warneri	1	
GPR-B	*Aneurinibacillus* species	2	141 (33.3)
	Bacillus cereus	2	
	Bacillus circulans	2	
	Bacillus firmus	3	
	Bacillus lentus	5	
	Bacillus species	118	
	Brevibacillus species	5	
	Geobacillus species	2	
	Unidentified Gram (+) bacilli	1	
	Unidentified Gram (+) branched bacilli	1	
GPR-C	*Brevibacterium* species	10	58 (13.7)
	Cellulomonas species	12	
	Corynebacterium species	30	
	Corynebacterium ulcerans	1	
	Rhodococcus species	5	
GPR-L	*Lactobacillus* species	4	4 (0.9)
L-Ag	*Legionella* antigen	13	13 (3.1)
Mold	Mold	18	22 (5.2)
	Penicillium species	1	
Yeast	*Candida* species	3	

*Microorganisms were classified as follows. GNR-F, Gram-negative rods-fermentor; GNR-NF, Gram-negative rods-nonfermentor; GPC-E, Gram positive coccus-enterococcus; GPC-M, Gram-positive coccus-micrococcus; GPC-S, Gram-positive coccus-staphylococcus; GPR-B, Gram-positive rods-bacillus; GPR-C, Gram-positive rods-corynebacterium; GPR-L, Gram-positive rods-Lactobacillus; L-ag, Legionella antigen.

Cultured microorganism and features

From 429 sampling sites, 624 sample cultures were investigated. Positive rate for any microorganism was 63.5% (396/624). Of these, four pathogens were identified. The others were environmental or normal flora, which are all susceptible to antibiotics (Table 4).

When we described the positive rate according to type of devices and participating ambulance, positive rate was 69.2% (9/13 ambulances) for airway devices which are a kind of critical devices, 92.3% (12/13 ambulances) for breathing devices which are a kind of semi-critical devices (Table 5).

DISCUSSION

The prevalence rate for microorganisms in a metropolitan ambulance surveillance was 49%, of which a few were pathogenic and most environmental or normal flora. This prevalence rate is not likely to be important, unless in critical or semi-critical devices. Medical devices in ambulance are classified into critical, semi-critical, and non-critical. Critical devices like intubation equipment, which should be sterilized until use, showed a 15.4% positive rate. 45.2% of semi-critical devices sampled were also positive. This finding is a surrogate marker for poor infection control for ambulance equipment (1, 2). Critical and semi-critical devices should be sterilized to clear up all microorganisms. A disposable device will be an alternative option for this goal (5). Non-critical devices include any external monitor apparatus for ECG, defibrillator, and so on. These devices are not important even though there are any microorganisms contaminated. Risk stratification-based surveillance (RSS) will guide us to make a feasible approach for maintenance of disinfection and quality.

Ambulance apparatus or driver's sides are classified into non-critical devices, generally not needing any sterilizing. For example, ambulance driver's sides showed very high contamination rate (73.1%). These findings are not serious.

Environmental microorganisms also will be problematic for immune compromised patients (9). However, environmental flora like *Acinetobacter* or *Pseudomonas*, which usual grow in soil or water, were found in this study. Those flora mean that minimum cleaning and washing for the ambulance was insufficient. This finding suggests disinfection for ambulances was poor.

Four pathologic microorganisms were indentified (0.9%). MRSA was from the driver's site and MRCoNS was from the stretcher bar. These pathogens should not be present in ambulances and devices. Ambulance crews as well as drivers take part in transfer of patients, which can deliver pathogen to new patients from these side devices. MRSA has been known to be a common pathogen in hospital-based surveys, particularly in intensive care units (10). In recent reports, nosocomial MRSA infections are spreading to community, which are very different

Table 5. Prevalence of microorganism culture by ambulance, equipment and device

Equipment and devices	Sample	Positive sample		Positive ambulance		A	B	C	D	E	F	G	H	I	J	K	L
	No.	No.	%	No.	%												
Airway devices	105	37	35.2	9	69.2												
Laryngoscope blade	15	7	46.7	5	38.5	+				+			+	+	+		
Laryngoscope handle	15	5	33.3	3	23.1		+								+	+	
LMA cuff	15	4	26.7	2	15.4									+	+		
Intubation tube	15	4	26.7	2	15.4									+		+	
Suction tip	14	4	28.6	3	23.1		+								+	+	
Water in suction bottle	18	9	50.0	4	30.8									+	+	+	
Oropharyngeal airway	13	4	30.8	4	30.8			+					+	+	+		
						0.0											
Breathing devices	140	71	50.7	12	92.3												
Nasal prong	17	8	47.1	4	30.8									+	+	+	+
Facial mask	14	5	35.7	4	30.8							+			+	+	+
BVM mask	17	10	58.8	6	46.2		+	+				+		+	+	+	
BVM bag	17	13	76.5	9	69.2		+	+	+			+	+	+	+	+	+
Oxygen gate connector	15	4	26.7	2	15.4									+		+	
Oxygen generator	15	6	40.0	4	30.8		+			+					+		+
Water in oxygen generator	28	14	50.0	12	92.3	+	+	+	+	+		+	+	+	+	+	+
Bottom of oxygen generator r-inside	17	11	64.7	7	53.8	+		+	+			+		+	+		+
						0.0											
Circulation devices	104	84	80.8	12	92.3												
ECG Line	17	12	70.6	8	61.5	+		+				+		+	+	+	+
Handle of AED	20	15	75.0	8	61.5	+				+		+		+	+	+	+
Button of AED	23	21	91.3	11	84.6	+	+	+	+	+		+		+	+	+	+
Handle of sphygmomanometer	26	21	80.8	8	61.5	+				+		+	+	+	+	+	+
Detector of pulse oxymeter	18	15	83.3	10	76.9		+	+	+	+		+	+	+	+	+	+
Other devices	207	164	79.2	13	100.0												
Splint for upper extremity	16	12	75.0	9	69.2	+	+		+			+		+	+	+	+
Splint for lower extremity	19	13	68.4	7	53.8		+						+	+	+	+	+
Cervical collar, back of head	16	13	81.3	7	53.8				+	+		+	+	+		+	+
Cervical collar, back of neck	17	16	94.1	7	53.8				+	+		+	+	+		+	+
Cervical collar, front of neck	17	16	94.1	7	53.8				+	+		+	+	+		+	+
Cervical collar, front of inside	14	14	100.0	8	61.5			+	+	+		+	+	+		+	+
Spine board	22	20	90.9	11	84.6	+	+	+		+		+	+	+	+	+	+
Patient's side door handle-1	20	16	80.0	9	69.2	+			+	+		+	+	+	+	+	+
Patient's side door handle-2	17	11	64.7	7	53.8	+						+	+	+	+	+	+
Stretcher car handle	17	12	70.6	8	61.5	+		+				+	+	+	+	+	+
Stretcher car side bar	18	16	88.9	11	84.6	+		+	+		+	+	+	+	+	+	+
Surface of stethoscope	14	5	35.7	4	30.8							+		+	+		+
Ambulance apparatus	68	40	58.8	11	84.6												
Extractor fan	13	4	30.8	4	30.8	+							+			+	
Air conditioner	14	2	14.3	1	7.7								+				
Steering wheel	20	16	80.0	9	69.2	+				+	+	+	+	+	+	+	+
Driver's side door handle	21	18	85.7	10	76.9	+			+	+		+	+	+	+	+	+

LMA, laryngeal mask airway; BVM, bag valve mask; ECG, electrocardiography; AED, automatic external defibrillator.

from hospital-acquired MRSA in terms of molecular analysis or clinical risk factors and features (11, 12). In this study, only one sample was MRSA positive, which was not identified on the basis of molecular biologic analysis.

The positive rate for MRSA in an ambulance sample conducted in the USA was 12.4%, which was very high compared to that of our study. However, our study was conducted using samples of devices and ambulance apparatus, not from the human body including hands, which are very relevant for MRSA infection. For future studies, to investigate the positive rate of MRSA, we should test samples from hands of ambulances crews.

Another pathologic microorganism was *K. pneumoniae*, which was extended spectrum beta lactamase (ESBL) positive. These bacteria were cultured from water in the suction bottle and surface of a bag-valve-mask bag, which means these can cause pneumonia in patients directly. *K. pneumoniae* also may cause septicemia and septic shock in the immune compromised host (13, 14). Although the identified pathogens were few, strict infection control should be emphasized.

This study has limitations. The number of selected ambulances was 13 (11.1%), which was conveniently sampled. Therefore, study results could be biased from selection method. In particular four ambulances were washed using alcohol and tap water before sampling, which could have affected the results as rou-

DOI: 10.3346/jkms.2011.26.1.124

tine practice. However, the positive rate of normal flora was similar in medical devices between pre-washed ambulances and non-washed ambulances because the most of medical devices were not washed or sterilized.

Different EMS systems and infection control guidelines maybe there, which also make us this result to be generalized to external world. This study was not related with infection rate or contamination rate for patients transported by these ambulances. Therefore these results are not related with clinical outcomes.

The risk stratification-based surveillance for contamination in metropolitan ambulances showed very high prevalence of environmental and normal flora infection in critical and semi-critical devices. And a few pathogens were also found. All kinds of pathogens are important to infection control for non-critical devices in ambulance as well as semi-critical, or critical. For critical devises, all normal flora are serious in terms of contaminated devices and should be targeted for being sterilized.

To prevent the ambulance from being a source of contamination, more strict infection control and monitoring protocol should be implemented.

ACKNOWLEDGMENTS

All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. We would like to thank and acknowledge the contributions of Emergency Medical Technicians (Doo Ho Kim and Yeon Jeong Cho) of Seoul National University Hospital on sampling and the Division of Rescue and Emergency Medical Service, National Emergency Management Agency for cooperation.

This study was financially supported by the office of Mrs. Ae Joo Lee, a member of National Assembly. All authors (Noh H, Shin SD, Kim NJ, Oh HS, Joo SI, Kim JI, Ro YS, and Ong ME) are not related with any other conflicts of interest in this study.

REFERENCES

1. Greenwood D, Slack RB, Peutherer JF. *Hospital infection. In: Greenwood D, editor, Medical microbiology: a guide to microbial infections: pathogenesis, immunity, laboratory diagnosis, and control. 16th ed. Edinburgh, NY: Churchill Livingstone 2002; 662-9.*
2. WHO. *Prevention of hospital-acquired infections. A practice guide, 2nd ed. Department of communicable disease, Surveillance and response. Available at http://www.who.int/csr/resources/publications/drugresist/whocdscsreph200212.pdf [accessed on 1 Jun 2010].*
3. Pittet D, Tarara D, Wenzel RP. *Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. JAMA 1994; 271: 1598-601.*
4. Nigam Y, Cutter J. *A preliminary investigation into bacterial contamination of Welsh emergency ambulances. Emerg Med J 2003; 20: 479-82.*
5. Roline CE, Crumpecker C, Dunn TM. *Can methicillin-resistant Staphylococcus aureus be found in an ambulance fleet? Prehosp Emerg Care 2007; 11: 241-4.*
6. Alves DW, Bissell RA. *Bacterial pathogens in ambulances: results of unannounced sample collection. Prehosp Emerg Care 2008; 12: 218-24.*
7. Block SS. *Chemical disinfection of medical and surgical materials. In: Block SS, editor, Disinfection, sterilization, and preservation. 4th ed. Philadelphia: Lea & Febiger 1991; 617-41.*
8. The Information Resource for the Emergency Management Industry. *Ambulances-current AMD Standards. Available at http://www.idsemergencymanagement.com/emergency_management/corporate/ambulance_manufacturers_division_/ambulance_manufacturers_division_/20_0/g_supplier_5.html [accessed on 22 Nov 2009].*
9. Jarvis WR. *The epidemiology of colonization. Infect Control Hosp Epidemiol 1996; 17: 47-52.*
10. National Nosocomial Infections Surveillance System. *National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 to June 2002, issued August 2002. Am J Infect Control 2002; 30: 458-75.*
11. Herold BC, Immergluck LC, Maranan MC, Lauderdale DS, Gaskin RE, Boyle-Vavra S, Leitch CD, Daum RS. *Community-acquired methicillin-resistant Staphylococcus aureus in children with no identified predisposing risk. JAMA 1998; 279: 593-8.*
12. Kowalski TJ, Berbari EF, Osmon DR. *Epidemiology, treatment, and prevention of community-acquired methicillin-resistant Staphylococcus aureus infections. Mayo Clin Proc 2005; 80: 1201-7.*
13. Chisti MJ, Tebruegge M, La Vincente S, Graham SM, Duke T. *Pneumonia in severely malnourished children in developing countries-mortality risk, aetiology and validity of WHO clinical signs: a systematic review. Trop Med Int Health 2009; 14: 1173-89.*
14. Meatherall BL, Gregson D, Ross T, Pitout JD, Laupland KB. *Incidence, risk factors, and outcomes of Klebsiella pneumoniae bacteremia. Am J Med 2009; 122: 866-73.*

AUTHOR SUMMARY

Risk Stratification-based Surveillance of Bacterial Contamination in Metropolitan Ambulances

Hyun Noh, Sang Do Shin, Nam Joong Kim, Young Sun Ro, Hyang Soon Oh, Se Ik Joo, Jung In Kim, and Marcus Eng Hock Ong

This study was performed to know the risk-stratification-based prevalence of bacterial contamination of Seoul Metropolitan City-Fire department's ambulance vehicle surfaces, equipment, and materials. Total 13 out of 117 ambulances (11.1%) were sampled and 33 sites per each ambulance were sampled and specific identification was performed. We categorized sampling sites into risk stratification-based groups (Critical, Semi-critical, and Non-critical equipment) related to the likelihood of direct contact with patients' mucosa. The prevalence (positive/number of sample) of bacterial contamination in critical, semi-critical airway, semi-critical breathing apparatus group was as high as 15.4% (4/26), 30.7% (16/52), and 46.2% (48/104), respectively. Despite current formal guidelines, critical and semi-critical equipments were contaminated with pathogens and normal flora. This study suggests the need for strict infection control and prevention for ambulance services.

DOI: 10.3346/jkms.2011.26.1.124